Cable-Augmented, Quad Ligament Tenodesis Scapholunate Reconstruction

Gregory I. Bain, MD[1] Adam C. Watts, MBBS[2] James McLean, MBBS, MS[3] Yu C. Lee, MBBS[3] Kevin Eng, MBBS[4]

[1] Department of Orthopaedic Surgery, Flinders University of South Australia, South Australia, Australia
[2] Department of Orthopaedics, Wrightington Hospital, Lancashire, United Kingdom
[3] Department of Orthopaedics and Trauma, Royal Adelaide Hospital, Adelaide, Australia
[4] Barwon Orthopaedic Research Unit, Geelong University Hospital, Geelong, Victoria, Australia

Address for correspondence Gregory I. Bain, MD, 196 Melbourne Street, North Adelaide 5006, South Australia, Australia (e-mail: greg@gregbain.com.au).

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Abstract

Maintaining reduction of the scapholunate interval after reconstruction can be difficult. The authors performed scapholunate reconstruction using tensionable suture anchors in 8 patients. The anchors provide a fixed cable that both fixes the graft, and reduces the scapholunate diastasis and maintains reduction. The flexor carpi radialis tendon graft stabilizes not only the volar scaphotrapezial ligament, and dorsal scapholunate ligament, but also the dorsal intercarpal and dorsal radiocarpal ligament. The Berger flap is closed using an ulnar advancement capsulodesis that further reinforces the dorsal intercarpal and dorsal radiocarpal ligament. The mean pain score improved from 5.8 to 2.1. Mean extension was 56° (91% of contralateral side), flexion 44° (70% of contralateral side), and grip strength was 41kg (95% of the contralateral side). The mean scapholunate angle was 71°, radiolunate angle 16° and scapholunate interval 3.0 mm. The cable augmented, quad ligament scapholunate ligament reconstruction offers theoretical advantages but long term follow up is required.

Keywords
- scapholunate dissociation
- carpal instability
- tensionable anchors

Traumatic injury of the wrist may result in a scapholunate interosseous ligament (SLIL) tear. A spectrum of injury exists, but if the scapholunate ligament is torn, with insufficient tissue to repair, the articular cartilage is preserved and the scaphoid and lunate are reducible, ligament reconstruction can be considered.[1,2]

Brunelli utilized the flexor carpi radialis (FCR) tendon for reconstruction of scaphoid ligamentous stabilizers[3]; the volar scaphotrapezial ligament (vSTTL) distally and the dorsal SLIL proximally. Van den Abbeele[4] modified this procedure to loop the graft through the dorsal radiocarpal ligament and secured back to itself over the lunate, avoiding bridging the radiocarpal joint which may limit flexion.[5]

Good clinical results have been demonstrated from previous reconstruction techniques using the FCR.[6] However, it relies on kirschner wire (K-wire) fixation to hold the reduction in the short term. In the senior author's experience, it was common for persistent diastasis and degenerative arthritis following this procedure. The following modifications were therefore instituted.

1. Utilizing tensionable anchors to tighten the vSTTL reconstruction
2. Utilizing tensionable anchors to reduce and stabilize the scapholunate interval
3. Including the DIC ligament in the SL reconstruction, as it is an important secondary stabilizer of the SL interval

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4. Closing the Berger ligament-sparing surgical approach with a V-Y advancement.

Patients and Methods

Eight patients were prospectively followed for two years. The mean age was 50 years at the time of injury (range 32–61) and all were male. The mechanism of injury was motor vehicle accident ($n = 4$), or fall ($n = 4$). In five patients the dominant wrist was injured. Two patients underwent surgery within two weeks of injury, four patients had delayed presentation with surgery between two to six weeks, and two had surgery beyond six weeks (3 and 8 months). Seven were employed as manual workers.

The patients were independently assessed using pain scoring on an Astra slide (range 1–10), range of motion, grip strength and radiological parameters.

Surgical Technique

The *indications* for our technique are those with symptomatic scapholunate instability from Wolfe grade II through to IV (II-dynamic, III-scapholunate dissociation, IV-Reducible DISI).[2] The technique is suitable for reconstruction of acute and chronic injury.

Our technique is *contra-indicated* in patients with a fixed DISI deformity, degenerative change and in patients with a fracture or avascular necrosis of the lunate or scaphoid. Ulnar translocation of the carpus is also a contra-indication as this procedure does not reconstruct the volar extrinsic wrist ligaments. Patients with these conditions should be considered for a scapholunate advanced collapse salvage procedure.[7]

A diagnostic wrist arthroscopy is performed to confirm the diagnosis and assess whether there is instability of the scapholunate ligament, a ligament that is repairable, a reducible interval, and if there is degenerative arthritis.[8] Distal translation of the scaphoid can be assessed by identifying a step between the scaphoid and the lunate. This may be best seen in the ulnar midcarpal portal. Joysticks can be placed into the scaphoid and lunate to assess reducibility.

The wrist is approached through a dorsal midline incision. The third extensor compartment is opened and the extensor pollicis longus tendon mobilised. The fourth extensor compartment is exposed. A Berger ligament sparing dorsal capsulotomy is performed.[9] (►**Fig. 1a**,**b**,**c**)

Fibrous tissue at the scapholunate interval is debrided. The reducibility of the scapholunate interval is assessed by manipulation of the wrist and by using K-wires as joysticks. The dorsal capsule of the hyper-extended STT joint is released if reduction of the scapholunate interval is difficult. The dorsal distal crest of the lunate is debrided in preparation for the FCR graft, to increase graft to bone healing and prevent dorsal impingement with wrist extension.

A 5cm volar wrist incision is performed over the distal FCR tendon. The FCR sheath is incised and the floor of this sheath is opened to the scaphoid tubercle. It is not necessary to incise the volar wrist ligaments. The FCR tendon is exposed via 1cm transverse incisions and split longitudinally into halves with the aid of a strong monofilament suture. One half of the FCR tendon is divided proximally at the musculotendinous junction and delivered into the distal wound. A grasping suture is placed into the free end of the graft.

A guide-wire is passed under fluoroscopic guidance from just proximal to the scaphoid waist dorsally to exit at the volar scaphoid tubercle. The guide wire is overdrilled with a 3.5mm cannulated drill. The FCR tendon graft is delivered through the tunnel with the aid of a suture passer to exit through the dorsal scaphoid.

The tendon is then stitched with a Magnumwire (ultra high molecular weight polyethylene fiber suture, ArthroCare Inc, Austin, Texas, USA) using a modified bunnel grasping suture as close as possible to where the tendon exits the bone tunnel. Next the scaphoid and lunate anchor sites are prepared with a 3mm drill at the native attachment of the scapholunate ligament. The drill holes are placed divergently oblique to ensure that the anchor will not bottom out in the carpal bones (►**Fig. 2**). The Magnumwire sutures are loaded on to an Opus Labrafix Suture Anchor (ArthroCare Inc, Austin, Texas, USA), and the anchor locked into the anchor site on the scaphoid by firing the device once.

The suture can now be tensioned using a mechanical ratchet, which draws the FCR graft through the bone tunnel,

Fig. 1 Dorsal capsulotomy and capsuloplasty. **(a)** Dorsal carpal ligaments, Dorsal intercarpal ligament (DICL) and Dorsal radiocarpal ligament (DRCL). **(b)** Capsular release as described by Berger.[9] **(c)** Exposure of the carpus with the ligament sparing approach.

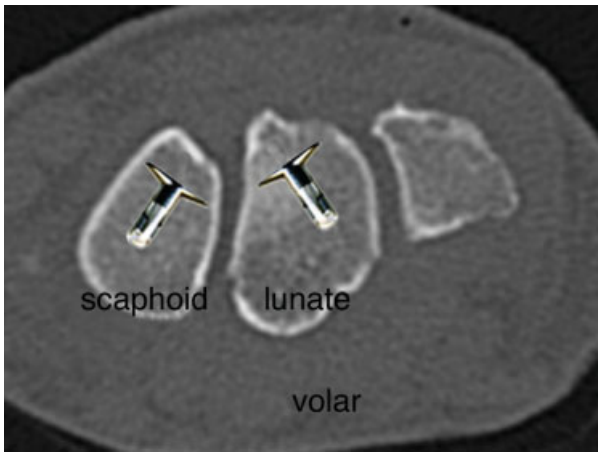

Fig. 2 Axial image of the proximal carpal row. *Arrows* demonstrate oblique angle of anchor insertion to ensure complete seating without penetration of the far cortex.

thereby tensioning the graft on the volar aspect and providing a taut reconstruction of the vSTTL complex. (►**Fig. 3a**) The STT joint is placed into flexion as the suture is advanced through the anchor. We do not aim to over-tighten the FCR graft, but to reduce the STT joint that has a tendency to hyperextension. The anchor gun is then fired twice to lock the suture into the anchor, and the gun introducer removed, leaving the trailing ends of the suture attached to the scaphoid anchor.

The trailing suture ends can now be loaded on to a second Opus Labrafix Anchor that is inserted into the lunate anchor site (►**Fig. 3b**,**c**). Tensioning and then locking this suture reduces the scapholunate interval (►**Fig. 3d**). As the anchors are placed into the anatomical attachment sites of the scapholunate ligament, when the suture is tightened via the ratchet gear, the scapholunate diastasis, rotation and flexion is corrected. This high tension suture remains a fixed cable over the dorsal aspect of the scapholunate interval, reinforcing the ligament reconstruction.

The gun is unloaded and the trailing ends of the sutures from the lunate anchor are used to secure the free end of the FCR graft to the lunate. The free end of the FCR graft is passed from deep to superficial through the DRCL and doubled back to the radial side of the wrist to reinforce the DICL (►**Fig. 3e**). Tension tightens the DRCL, as popularised by the 3 ligament tenodesis.[5]

The FCR graft is sutured to the soft tissues over the dorsal ridge of the scaphoid and the excess graft is excised. We pass a 1.6mm K-wire from the scaphoid to the capitate to control scaphoid flexion (►**Fig. 4**). A posterior interosseous nerve neurectomy is not performed. The position of the carpus is assessed using fluoroscopy to confirm adequate reduction.

An ulnar advancement capsulodesis is performed. This involves the dorsal capsular radial-based flap being advanced in an ulnar direction, in a V-Y fashion to tighten the entire dorsal capsule (►**Fig. 5**). This further reinforces the DICL and DRCL. A splint is applied.

Postoperative Management

At one week a short arm (below elbow) cast is applied. It is maintained for the following 7 weeks. Then the cast and K-wire are removed, the patient is provided with a splint for comfort and rehabilitation is commenced.

Results

At independent review the patients reported they were satisfied with the outcome of surgery, with an mean satisfaction score of 7.6/10 (range 5–9). The mean pain score was pre-operatively 5.8, and improved to 2.1 at 2 years.

Mean extension pre-operatively was 51 degrees and at final follow-up was 56 degrees (91% of contralateral). The mean flexion pre-operatively was 48 degrees and at final follow-up was 44 degrees (70% of contralateral side). The mean final grip strength was 41 kgs (95% of contralateral side),

The radiological measures were not as favorable as the clinical results. The mean scapholunate angle was 71 degrees, radiolunate angle 16 degrees, and scapholunate interval 3mm. Seven patients had an increased scapholunate angle at 6 months. Three of these seven had a scapholunate interval greater than 3mm. This suggests that the anchor suture complex provides initial stability but the construct may not be resistant to cyclic loading.

There were no cases of avascular necrosis or fractures of the scaphoid or lunate. One patient had irritation from the K-wire that required removal at six weeks. No patients required further surgeries, and none are planned at this time.

Discussion

Maintaining normal carpal alignment following intrinsic intercarpal ligament injury remains a challenge. The dSLL is considered the primary stabilizer of the scapholunate interval.[10] The Quad ligament tenodesis reconstructs the vSTTL, dSLL ligament, tightens the DRCL and reinforces the DICL. The addition of the DICL is an advantage over the popular three-ligament tenodesis.[5] Many consider the DIC an important secondary stabilizer of the scapholunate interval.[10–12]

Previous techniques involve suturing the tendon with standard suture anchors and violation of the scapholunate joint surface with K-wires or screws. The tensionable anchors are a new generation of anchors. With a conventional anchor, the anchor is placed into the bone and the suture is passed through the ligament. *One* end of the suture passes though the anchor eyelet and then, in a *retrograde* direction, back to the second suture. To approximate the tendon to the anchor requires the surgeon to maintain the tension on the suture as it is tied. It is difficult to achieve perfect tension, and maintain this tension. The suture cannot be retensioned once it has been tied.

The normal visco-elastic properties of the tendon (creep) will result in subtle tendon lengthening.

In contrast, when using tensionable anchors, *both* sutures pass from the tendon *through* the anchor and advance in an *antegrade* direction. Rotation of the ratchet wheel advances

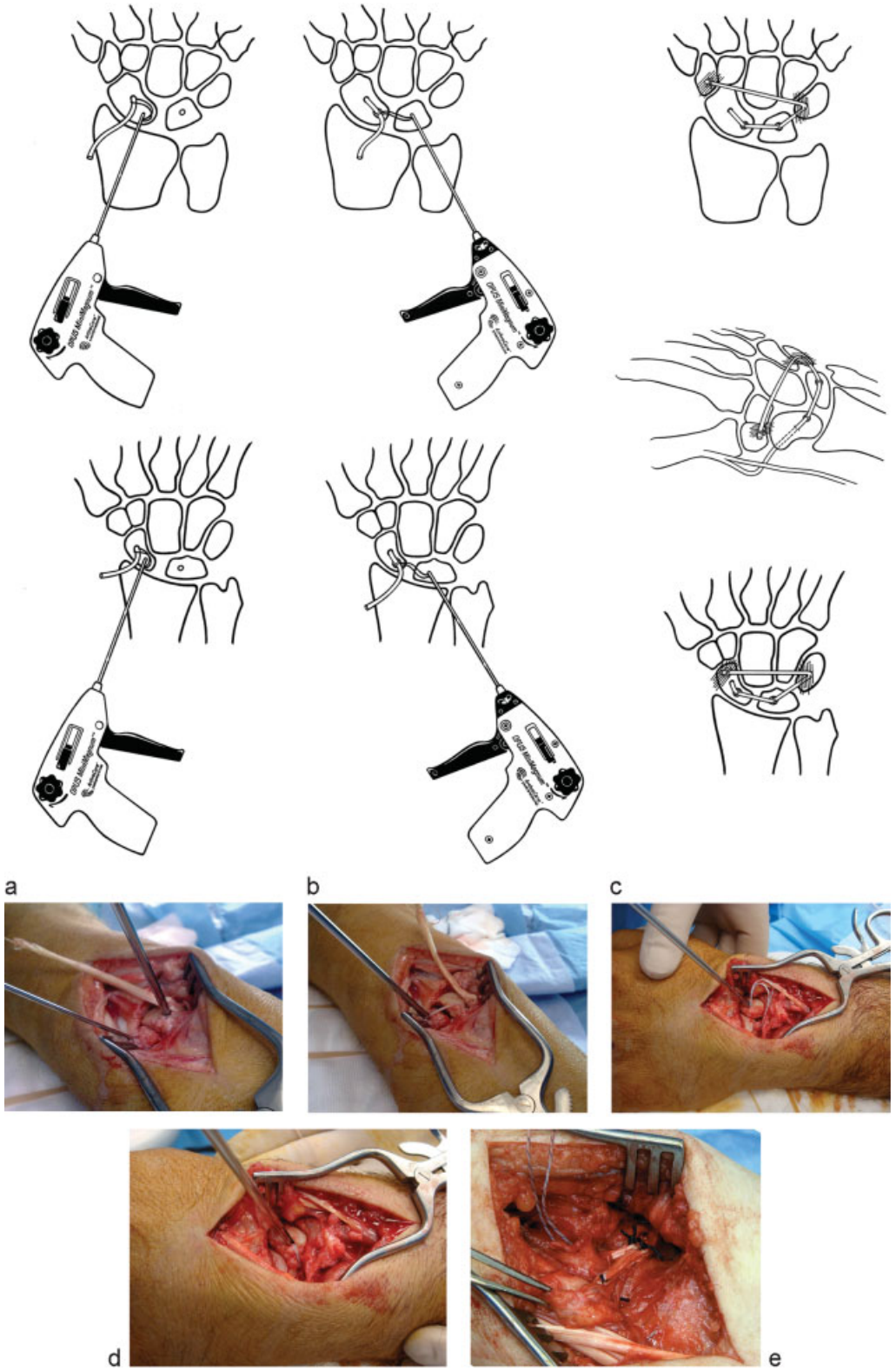

Fig. 3 Cable Augmented scapholunate reconstruction. **(a)** Tensioning of FCR graft (reconstructs vSTTL) which has passed through the scaphoid bone tunnel and stabilized to the first anchor placed into the attachment site of the dSLL. **(b)** Second anchor in the lunate dSLL attachment site. Tension on the suture reduces the scapholunate interval anatomically. **(c)** Anchors positioned in the anatomical attachments of the scapholunate ligament, prior to tightening **(d)** tightening of the "stacked anchors" docks the scaphoid onto the lunate. **(e)** The FCR graft is stabilized to the lunate, looping through the dorsal capsule over the triquetrum (tightens DRCL), then doubling back and stabilized to the dorsal ridge of the scaphoid (reconstructs the DICL).

Fig. 4 PA radiograph of the wrist reconstructed with the Cable Augmented, quad ligament tenodesis. **(a)** Initial injury, **(b)** at presentation 12 weeks after reduction, **(c)** immediately post-operatively, **(d)** 6-months post-operatively).

the suture mechanically drawing the tendon toward the anchor with fine control of tension. The surgeon can allow the viscoelastic properties of the ligament to be taken up within the system and then increase the tension again.

With the tensionable anchors the original suture can be inserted into the second anchor to create the concept of the "anchors in series." The anchors act both as a ligament to bone fixation for the tendon reconstruction and a scapholunate reduction device. The anchors and suture remain insitu to maintain the reduction and avoid the need for K-wires between the scaphoid and the lunate.

The distance between the scaphoid and the lunate is now fixed, but with an arc of motion. This is how a ligament works: As a tissue structure of tension, with a fixed maximal length.

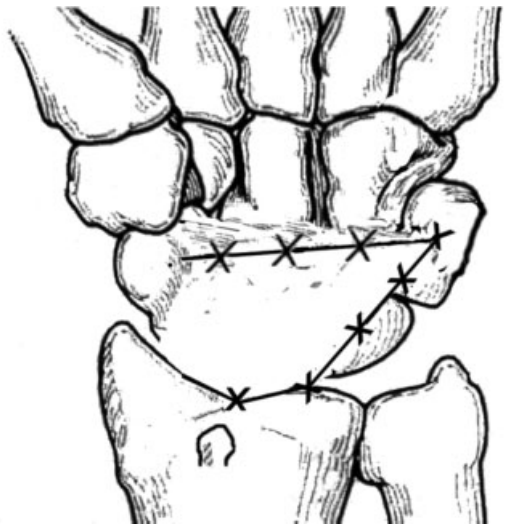

Fig. 5 Ulnar advancement capsulodesis with "waist coating" advancement of the dorsal capsule, to reinforce the DICL and DRCL.

The method of advancement to close the dorsal capsule is simple and is likely to be an advantage as it reinforces the DICL and DRCL.

The results achieved are comparable to previously published literature.[3,5,6,13] Our patients had a slight loss of mean flexion of 4 degrees. This was only small loss and may represent some of the flexion loss seen with closure of the berger flap, or may be due to our V-Y advancement repair of the berger flap.

Despite excellent clinical results in our series seven patients had poor radiographic parameters at 6 months. The behavior of the anchors during cyclic loading in the carpus has not been studied. These constructs require longer term follow up to establish their durability.

Conflict of Interest

None

Acknowledgments

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